

Austroassiminea lethae, gen. nov., sp. nov., a rare and endangered prosobranch snail from south-western Australia (Mollusca: Prosobranchia: Assimineidae)

by Alan Solem¹, Elizabeth-Louise Girardi¹, Shirley Slack-Smith² and George W. Kendrick²

¹Field Museum of Natural History Roosevelt Rd at Lake Shore Drive, Chicago, Illinois 60605, U.S.A.

²Western Australian Museum, Francis Street, Perth, W.A. 6000.

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Abstract

A few isolated freshwater seepage areas between Turner Brook north of Augusta and Ellen Brook north of Margaret River in the south-west corner of Western Australia support populations of *Austroassiminea lethae*, which is described as a new genus and species of the prosobranch family Assimineidae. Anatomical structures differentiate it from previously described assimineids and suggest strongly that it is a phylogenetic relict. Pleistocene fossils are known from several places on the coast, as far east as Point d'Entrecasteaux. Each of the three known living populations is small and in danger of destruction from agricultural or other human activity. Efforts are needed to preserve this important relict component of the Western Australian fauna.

Introduction

Subfossil specimens of a small "terrestrial" prosobranch were taken first at Cosy Corner by Barry R. Wilson in 1963. Subsequent collections by Anne Paterson (Brearley) from Turner Brook in 1971 and by Shirley Slack-Smith from Ellen Brook in 1975, have been supplemented by further collections in 1980 by Shirley Slack-Smith, George W. Kendrick and Mike Ellis. Materials adequate for description and tentative classification are now available.

Assimineids are common in South-east Asia and Indonesia through New Guinea and onto the Pacific Islands, but this is the first anatomically studied species for the family in Australia. A salt-marsh species from Tasmania and New South Wales, "*Assiminea*" *tasmanica* Tenison Woods, 1876, is placed correctly in the family Assimineidae; generic assignment must wait publication on its anatomy by Dr W. F. Ponder. The features of the new taxon, *Austroassiminea lethae*, combine characteristics of the two generally recognized subfamilies of the Assimineidae, and no closely related extralimital genera could be identified. There is a long history of exotic organisms having been introduced to Australia. Therefore, considerable efforts were made to compare this species with extralimital taxa. The occurrence of *Austroassiminea lethae* in presumed Pleistocene fossil soils from the south-western coast of Western Australia (Fig. 13) is additional strong evidence for it being an endemic faunal element.

The present study is a cooperative effort with different primary responsibilities: Alan Solem provided the systematic descriptions, comparisons, SEM analyses and photographs, and did much of the dissection work and supervision of the illustrations; Elizabeth-Louise Girardi worked extensively with illustrator Elizabeth Liebman and Alan Solem on the anatomical structures and interpretations; Shirley Slack-Smith is

primarily responsible for the data on ecological occurrence and field collections; and George W. Kendrick did much of the fossil collecting and provided data on the geology and interpretation of the deposits.

All specimens used in this study are presently located in the collections of the Western Australian Museum (WAM) and the Field Museum of Natural History (FMNH).

Ecological occurrence

All collections of active individuals have been in actual seepage films or splash zones by small freshwater streams near the coast. Fissured rocks or talus through which the water can trickle are present. Aestivating and recently dead individuals have been taken on logs, leaves and rocks immediately adjacent to such areas. These findings probably represent wide-foraging individuals stranded by increasing dryness. The main reservoir of the populations would be inside the boulder fissures or talus, where either a minor flow of water or very high humidity would prevail even in mid-summer drought. The source of this water is runoff and percolation from areas lying further up the drainage basin of each stream. In all cases the water drains from areas of limestone and, in some, directly from the contact zone between the limestone and the underlying granitic rock. The Turner Brook site involves present or proposed agricultural areas that are subject to chemical spraying and/or fertilizer applications. The effects of such chemicals on amphibious snails are not known. They are highly unlikely to be beneficial, and probably are quite harmful. The limited extent and thus small size of this population does not provide a margin for experimentation as to such effects. The immediate steps necessary to minimize the possibility of extinction occurring would be to ban chemical applications on the few hectares immediately involved in seepage drainage through the known live snail area.

Although the snails are clearly associated with freshwater seepage areas, the lack of any gill remnant, and the fact that they will at least temporarily seal to a log, leaf or rock, indicates that they are marginally terrestrial. All known live occurrences of *Austroassiminea lethia* are well above tidal or ocean spray influence. These snails are best considered to be amphibious in the same sense as the North American *Pomatiopsis* (see Dundee 1957). The limited and spotty distribution of *Austroassiminea lethia* is typical of such taxa, and also reflects the limited number of suitable habitat sites in south-western Western Australia.

Systematic review

The most recent reviews of the Assimineidae (Thiele 1927, 1929) provide a framework for generic reference. Abbott (1958) produced an excellent review of the Philippine members of the genus *Assiminea*, which gives entry to the widely scattered literature on this group. Known habitats range from mudflats through amphibious situations to dry upland forest areas. Habitat occurrence does not correlate with the admittedly form genera currently used. The most obvious anatomical features differentiating assimineids from members of the hydrobioid groups are their pectinate marginal tooth, relatively simple lateral teeth and general lack of basal denticles on the rachidian tooth of the radula. Unfortunately, few assimineids have been dissected in detail, so that only limited anatomical comparisons can be made with other genera.

Family Assimineidae

Genus *Austroassiminea* gen. nov.

Diagnosis: The simple snout without an accessory cape, absence of accessory basal plates for the lateral teeth, lack of basal denticles on the rachidian radular tooth, pectinate single marginal tooth, paucispiral operculum without posterior protrusions, retention of long tentacles, huge penis with bifurcate tip and internal vas deferens but no lateral protrusions, and simple female system combine aspects of the family-level units Assimineinae (= Syncerinae) and Omphalotropidinae as delineated by Abbott (1949, p. 262) and Tutuilanidae of Hubendick (1952). Most genera traditionally referred to these complexes are known from shell and operculum only. Radular cusps, shape of the verge, and external features of the head region have been recorded for a few taxa, but details of the internal anatomy equivalent to those presented here are not recorded in the literature. The form genera *Assiminea* Fleming 1828, *Paludinella* Pfeiffer 1841 and *Omphalotropis* Pfeiffer 1851, with which *Austroassiminea lethia* might be associated, differ in most of the above characters (see Abbott 1949, 1958).

Description: Foot not divided, a prominent lateral groove extending from mantle cavity to head. Tentacles long, with raised eyespots lateral to base. Snout of moderate length, no cape or shield present, terminating in two lips reaching slightly beyond mouth, which is a vertical slit. Operculum paucispiral, corneous, nucleus acentric, no trace of calcareous deposits. Radula taenioglossate. Rachidian tooth without basal denticles; normally 7 denticles on upper edge, central largest. Laterals multicuspid; inner with greater variation in denticle size, weak

protrusions on inner side of base which is shovel-shaped. No accessory basal plates. Outer lateral with flatter, tapering base, sharply recurved denticles. Marginal tooth fan-shaped, pectinate, with minute recurved denticles. Male with enormous verge having a bifurcated tip and internal vas deferens. An unusual release valve from the vas deferens enters the hindgut. Suprapallial structures of male system relatively simple. Female with small spermatheca, seminal receptacle a kinked area in upper oviduct; pallial oviduct large, U-shaped, with vaginal orifice near anus.

Type species: *Austroassiminea lethia* n. sp.

Remarks: Intertidal, supratidal, freshwater and terrestrial species of similar conchological mien from most continents have been referred to the Assimineidae and to the form genera *Assiminea* Fleming 1828, and *Paludinella* Pfeiffer 1841. Recorded data on these species consist mostly of shell and opercular features that are notoriously subject to convergent simplicity. Occasional outlines of radular denticles and the upper parts of the basal plates, or of the extended head and foot, plus an outline of the cephalic verge complete most available data. Abbott (1958) monographed the Philippine Islands *Assiminea*, greatly extending our knowledge of structure, although he was (p. 224) "...unable to satisfactorily work out the female genital system." In an earlier paper, Abbott (1949) described several new assimineids from the Mariana Islands and provided expanded definitions of the subfamilies Assimineinae (under the name Syncerinae) and Omphalotropidinae, even hinting that they might be separate families. Turner and Clench (1972) recorded some data on *Omphalotropis nebulosa* Pease 1872 and *Pseudocyclotus levis* (Pfeiffer 1855) from the Solomon Islands.

The level of recorded knowledge for extralimital taxa is thus meagre, which makes meaningful comparisons difficult. Since *Austroassiminea* agrees with the Assimineinae in snout and operculum, but with the Omphalotropidinae in length of eye stalk and pectinate marginal tooth on the radula, doubt is cast on the reality of current suprageneric categories in the Assimineidae. We choose to ignore the subfamily and tribal names of Thiele (1927, 1929), since they appear to be artificial pigeonholes based on inadequate evidence, and classify *Austroassiminea* only to family level. It is quite possible that monographic revisions will split the family or attach sections to other family units. Consideration of such changes is well beyond the scope of this study.

Data on the anatomy of some Pacific island taxa are given by Abbott (1949, 1958). Quick surveys of Melanesian and Polynesian assimineids in the alcohol collections at Field Museum of Natural History showed a pattern of these species having both a proboscoid cape and a deep posterior slit on the foot, characters that Abbott (1949, 262) used as subfamily features for the Omphalotropidinae. Both of these features are absent from *Austroassiminea lethia* (see Fig. 12). While some of the Pacific island taxa have similar-appearing shells, the above differences in external anatomy alone are sufficient to exclude congeneric classification of *Austroassiminea* with any of the genera based on Pacific island taxa that Abbott (1949) included in the Omphalotropidinae (*Omphalotropis* Pfeiffer 1841, *Paludinella* Pfeiffer 1841, *Electrina* Gray 1850, *Quadrasiella*

Moellendorff 1894, *Garrettia* Paetel 1873, *Allepithema* Tomlin 1931, *Thaanumella* Clench 1946, or *Wrayanna* Clench 1948). The pectinate marginal teeth of the radula in *Austroassiminea* are a major difference from the situation in *Assiminea* Fleming 1828, *Acmella* Blandford 1869, *Turbacmella* Thiele 1927, and *Conacmella* Thiele 1927, taxa that although lacking the proboscis cape and posterior foot slit, have much shorter eye-stalks and non-pectinate marginal teeth on the radula.

It is quite possible that these characters considered by Abbott (1949, 1958) as indicative of suprageneric categories will be shown to be less important when the family is revised, but such a revision cannot be undertaken at this time.

The combination of features listed for *Austroassiminea* in the diagnosis is very different from the combinations recorded for any of the above genera. This, combined with the extreme geographic isolation of *Austroassiminea* from potential relatives (see diagnosis of the species for comparisons), makes description of a new genus necessary.

The name *Austroassiminea* refers to both its geographic position and taxonomic relationship to the assimineid complex.

Austroassiminea lethae sp. nov.

(Figs. 1-12)

Type locality: Cosy Corner, Hamelin Bay, near Augusta, Western Australia, ca. 34° 15' 05" S, 115° 01' E, under tussocks of grass on granite cliffs near coast wet by seepage from limestone-granitic rock contact above.

Holotype: WAM 71.80, adult shell, probably a female. Collected by Anne Paterson (Brearley), 8 July 1971.

Paratopotypes: WAM 778.66, WAM 472.80, WAM 477.80, WAM 478.80, WAM 479.80, WAM 699.80, FMNH 200985, FMNH 200986.

Paratypes: Deepdene Cliffs, near Augusta, from seepage area, moss and *Agonis* leaf litter, foot of cliffs, ca. 34° 15' 09" S, 115° 03' E, WAM 476.80, FMNH 200987; Deepdene Cave area near Lakes Rat Hole, Cave 3, 0-0.1 m, WAM 1175.69, subfossil; Turner Brook near Deepdene Cliffs, ca. 34° 15' 09" S, 115° 03' E, WAM 475.70, WAM 694.80, FMNH 200989; entrance to Meekadorabbie Cave, Ellen Brook, 33° 54' 36" S, 114° 59' 40" E, Leeuwin-Naturaliste National Park, WAM 693.80, WAM 695.80, WAM 696.80; upstream from Ellensbrook homestead, under logs, 2-3 m above water level, WAM 700.80, WAM 701.80; below dam on Ellen Brook, WAM 697.80, WAM 698.80, FMNH 200988; Ellen Brook, ca. 33° 54' 10" S, 114° 59' 30" E, WAM 473.80; Sta. WA.284, banks of Ellen Brook, east of homestead, FMNH 200598. Fossil at: on the coast west of Strongs Cave, south end of North Point, 34° 09' 41" S, 115° 01' 23" E, WAM 68.385, WAM 81.19, FMNH 198759; Donnelly River mouth, ca. 0.5 m (0.8 km) south-east of the river mouth, ca. 34° 29' 24" S, 115° 40' 38" E, WAM 70.2691, WAM 70.2692; ca. 0.5 m (0.8 km) north of Windy Harbour townsite, quarry on south side of track to Salmon Beach, 34° 49' 14" S, 116° 00' 52" E, WAM 70.895, WAM 70.897, WAM 70.898.

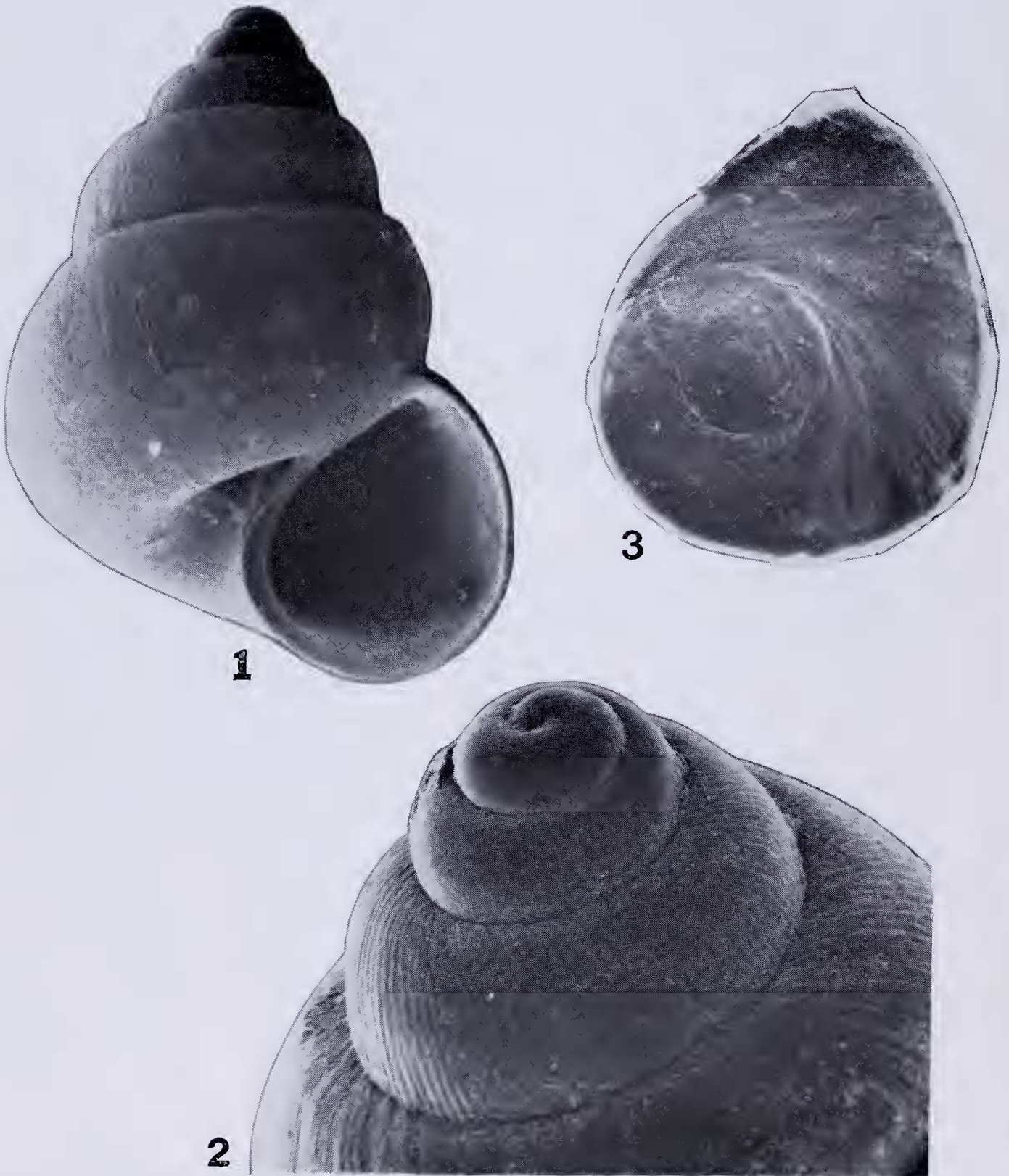
Diagnosis: The combination of smooth apex, moderate radial ribbing on the upper spire, frequent presence of peripheral spiral cords and weak spiral cords on the shell base, relatively open umbilicus of the shell; paucispiral corneous operculum without posterior projections; absence of basal denticles on the central tooth of the radula, comblike marginal tooth with clear slits; extremely large bifurcated penis without lateral protrusions, small spermatheca, and long tentacles effectively differentiate *Austroassiminea lethae* from geographically nearby taxa. *Hydrococcus graniformis* Thiele (1928, p. 374-5, 380, pl. 8, figs 10, a), described from the Swan River, Western Australia, has a multispiral operculum with central nucleus and posterior projection; a hydrobiid, rather than an assimineid radula; and a globose, rather than elongated, shell. "*Assiminea tasmanica* Tenison Woods 1876, reported from Tasmania north to Queensland (Hedley 1906, p. 527-8, Figs 27-30; Iredale and McMichael 1962, p. 43), and also south-western Australia (*teste* Ponder), has a generally banded shell without radial ribs, a nearly closed umbilicus, more acentric paucispiral operculum with posterior projection, and quite different lateral teeth on the radula. The New Zealand species, "*Assiminea vulgaris* (Webster 1905) and *Suterilla neozelanica* (Murdoch 1899), as summarized by Powell (1933), obviously differ in radula, nearly closed umbilicus, lack of shell sculpture and in basic habitat. Both are marine or strand line in association.

The long tentacles, lack of any lateral protrusions on the male verge, absence of basal denticles on the radular central tooth, open umbilicus, radial ribbing on the spire and freshwater habitat, effectively eliminate the possibility that *Austroassiminea lethae* might be based upon introduced examples of the British *Assiminea grayana* Fleming 1828.

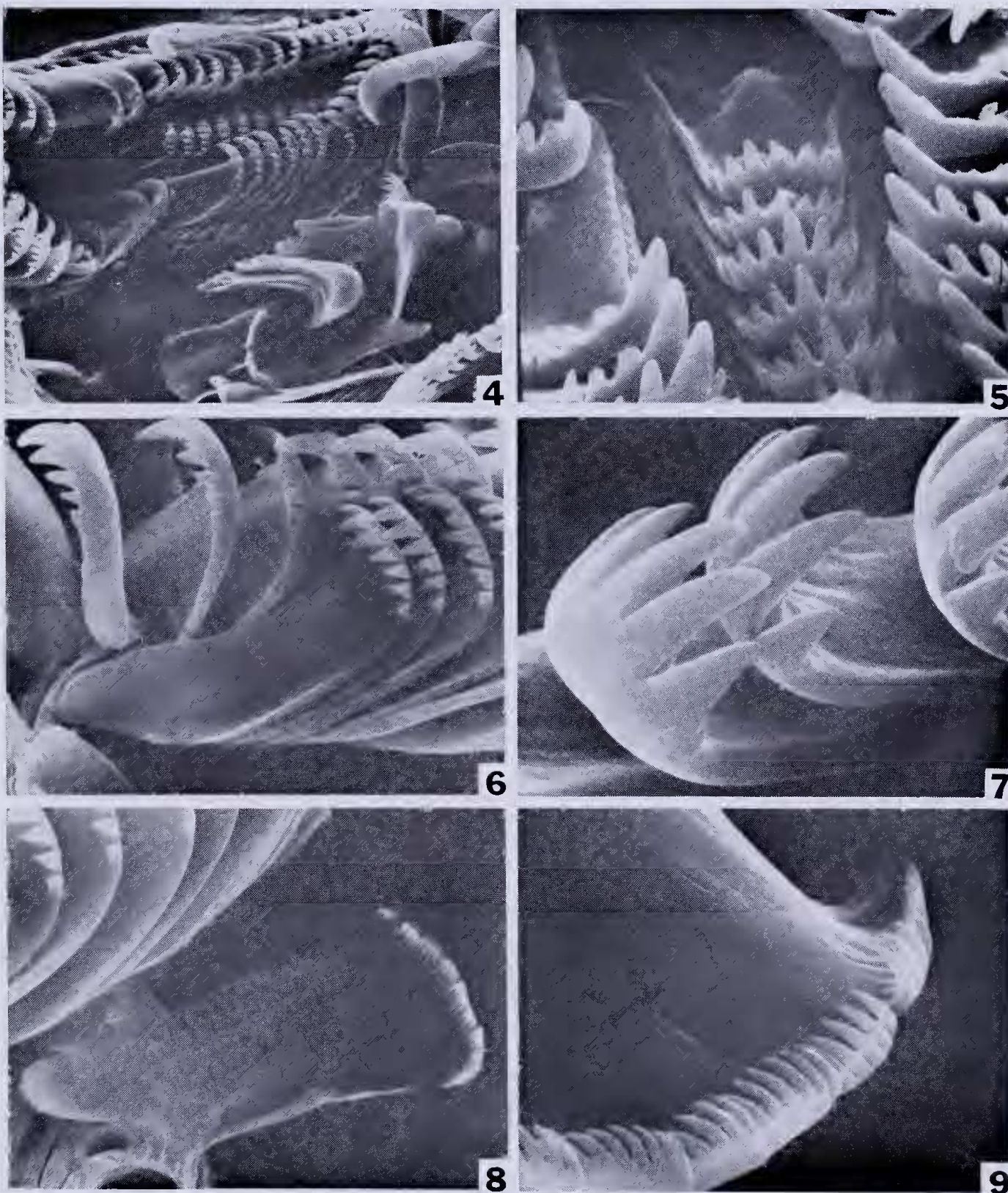
Description: Shell variable in shape, from squat ovate-conic to elongate-conic, spire angle generally uniform, H/D ratio 1.23-1.55 (mean 1.38). Males often smaller and squatter than females. Shell height 3.45-5.39 mm (mean 4.50 mm), diameter 2.60-3.78 mm (mean 3.26 mm). Apex (Fig. 2) smooth, upper spire with fine radial ribs that become irregular to absent on lower spire and body whorl (Fig. 1). Whorls 4 7/8- to 6 1/8- (mean 5 1/2-). Sutures well impressed, whorls evenly rounded, a weak (Fig. 1) to prominent spiral keel visible on periphery of penultimate and body whorls, sometimes weak spiral cords on shell base. Umbilicus narrowly open, without carina or keel. Lip of adults expanded, noticeably thickened on columellar and parietal walls (Fig. 1). Based on 227 adult specimens.

Operculum (Fig. 3) corneous, paucispiral, nucleus slightly acentric, without calcareous granules or posterior projections. Head of animal (Fig. 12) without unusual features. Eyespots (EY) lateral to base of tentacles (TE). Snout (SN) relatively short, ending in two expanded superior lobes (L) that extend in front of mouth (M). Edge of snout marked by a groove (BG) from mantle cavity. Foot (F) undivided, truncated in front, tapering posteriorly. Operculum (OP) mounted on a raised flap.

Radula taenioglossate, 7 teeth per row. Rachidian tooth (Figs 4, 5) normally with 7 cusps, median cusp slightly enlarged, sides of tooth with weak bumps, but no developed denticles. Centre base of rachidian



Figures 1-3.—*Austroassiminea lethata* sp. nov. 1—side view of Holotype WAM 71.80, x20.9. 2—spire of holotype, x54.3. 3—operculum of paratype, WAM 472.80, x42.2.



Figures 4-9.—*Austroassimineia letho* sp. nov. Radula of paratype WAM 472.80. 4—partially fragmented radula, x400. 5—central teeth, x1,335. 6—lateral teeth, x1,110. 7—side view of outer laterals, x4,000. 8—single marginal tooth, x1,270. 9—edge of comb marginal, x3,960.

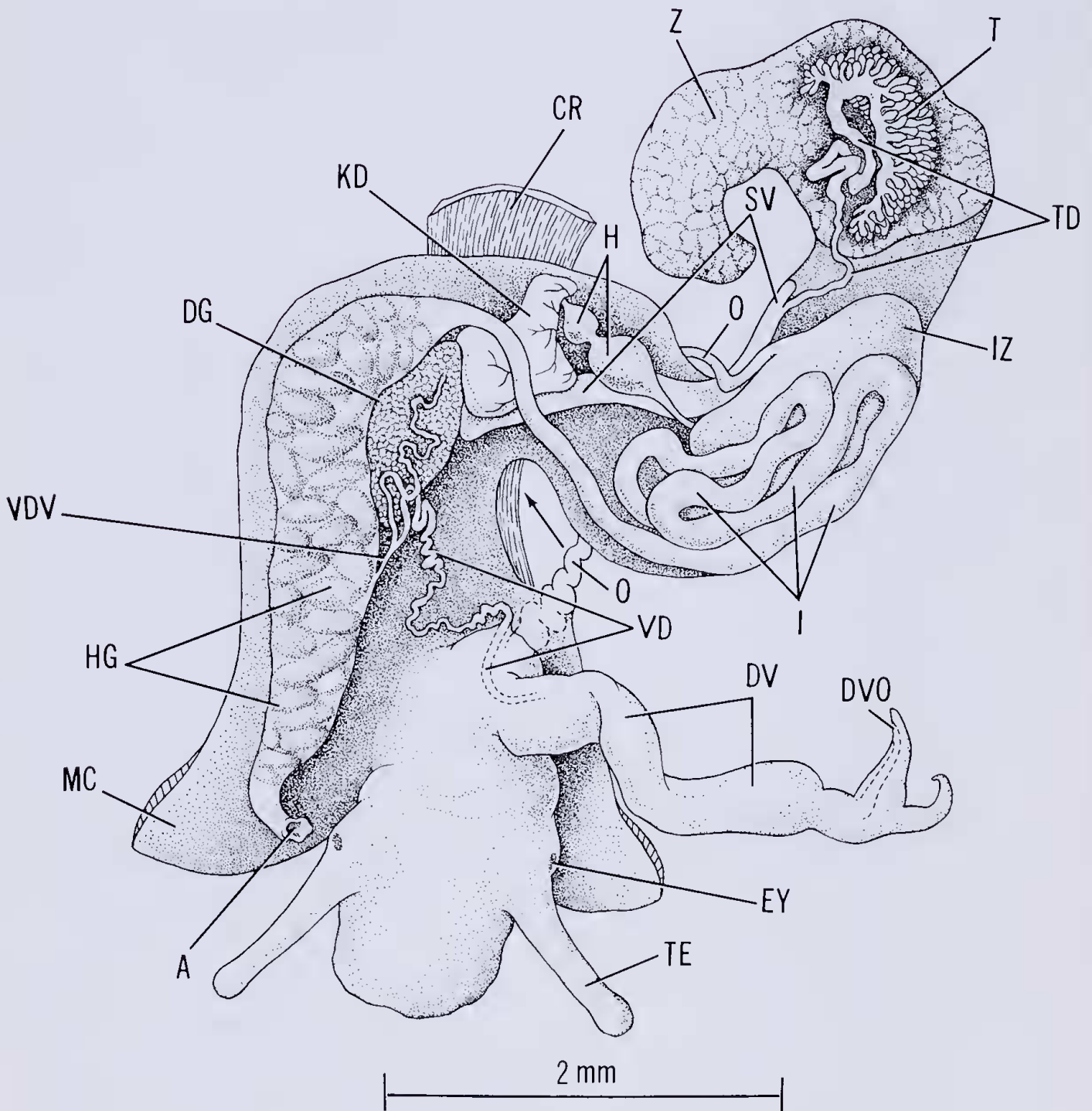


Figure 10.—*Austroassiminea lethia* sp. nov. Paratype WAM 472.80. Gross anatomy of male. Arrow indicates apex of mantle cavity. Drawing by Elizabeth Liebman. See Table 1 for explanation of labels.

slightly protruded, but without denticles. Inner laterals (Figs 4-6) with concave, shovel-shaped base; inner side of tooth with a row of low protrusions (Fig. 5, left), denticles asymmetrical with largest 2nd from inner side, gradually reduced in prominence outward, normally totalling six. Outer laterals (Figs 6-7) with base less concave, clearly tapered; sides of tooth without bumps or accessory denticles; upper

margin sharply recurved (Fig. 7) and bearing normally seven denticles that are less differentiated in size than those of the inner laterals. No accessory basal plates on either lateral tooth. Marginal (Figs 8-9) broad, relatively flat, base tapering as in outer lateral; edge split 7-8 times and thus pectinate, each pectination edge with sharply recurved, minute denticles, 4-7 in number.

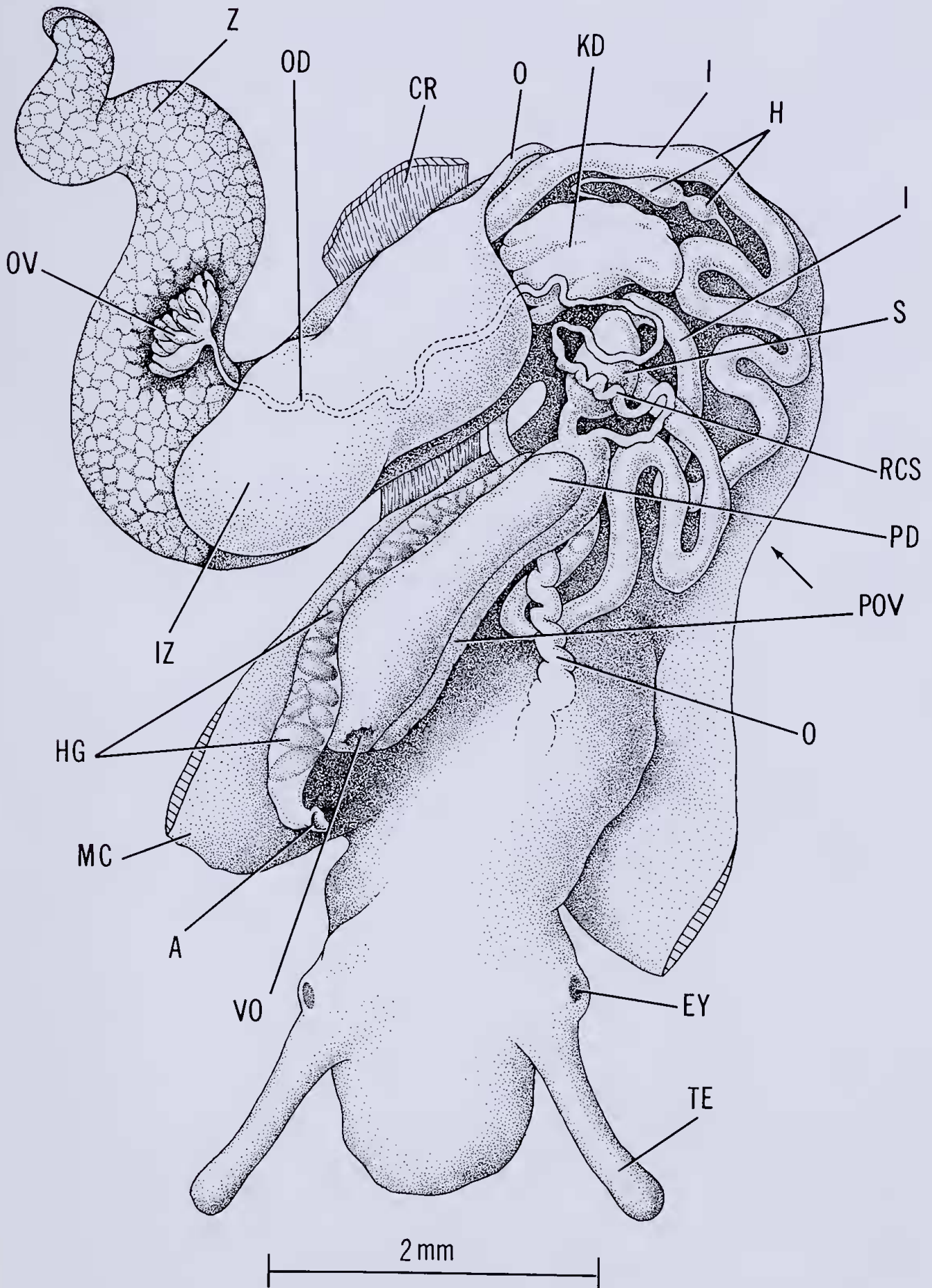


Figure 11.—*Austroassiminea lethae* sp. nov. Paratype WAM 472.80. Gross anatomy of female. Arrow indicates apex of mantle cavity. Drawing by Elizabeth Licbman. See Table 1 for explanation of labels.

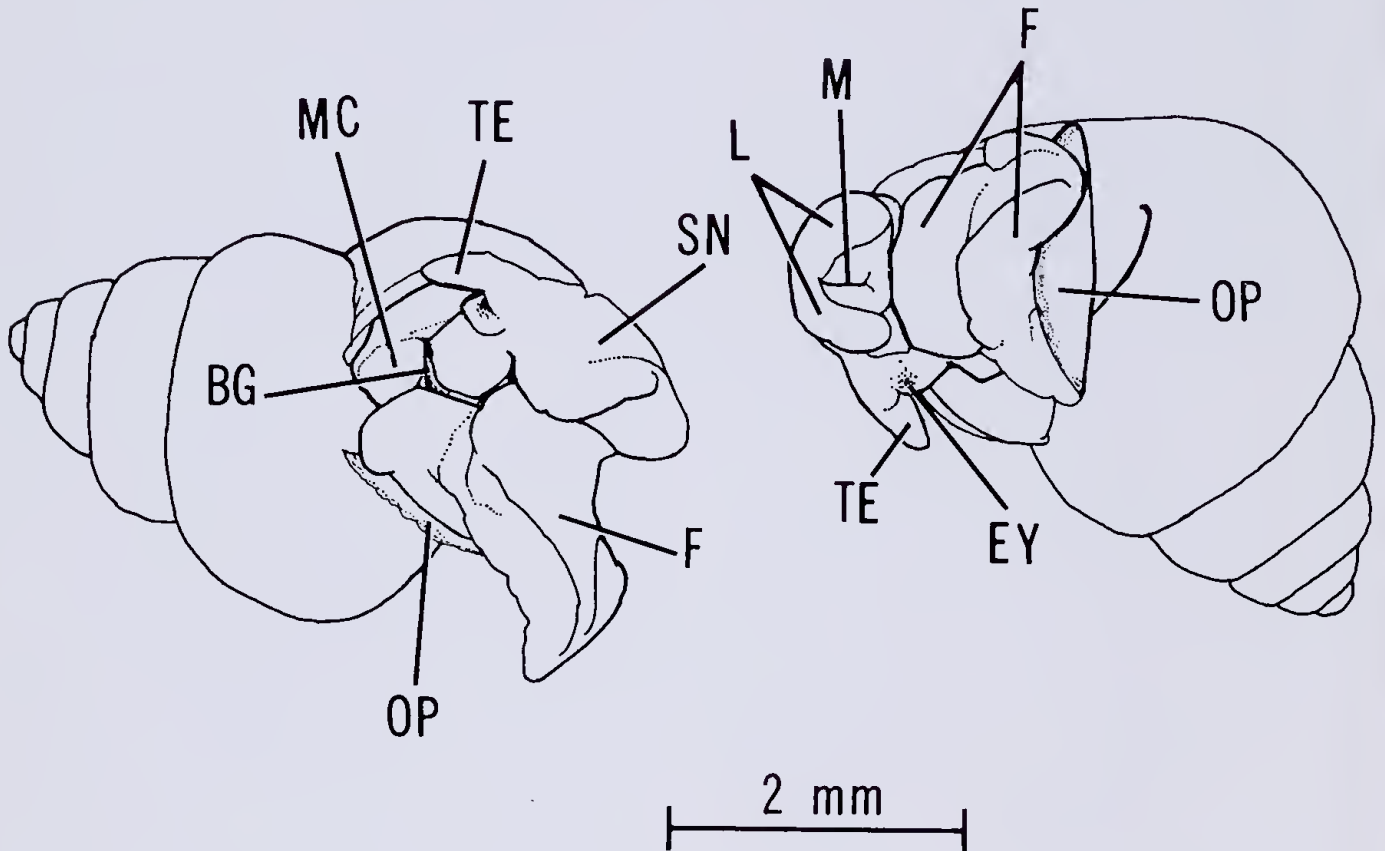


Figure 12.—*Austroassiminea lethra* sp. nov. Paratype WAM 694.80. Head and foot of preserved animal. Drawing by Linnea Lahlum. See Table 1 for explanation of labels.

Table 1

Explanation of anatomical labels

A	anus	OD	oviduct
BG	back groove	OP	operculum
CR	columellar retractor muscle	OV	ovary
DG	prostate gland	PD	dorsal lobe of oviduct
DV	verge	POV	ventral lobe of oviduct
DVO	external pore of verge	RCS	seminal receptacle
EY	eye spot	S	spermatheca
F	foot	SN	snout
H	heart	SV	seminal vesicle
HG	hindgut	T	testis
I	intestine	TD	testis duct
IZ	stomach	TE	tentacle
KD	kidney	VD	vas deferens
L	snout lobes	VDV	escape valve of vas deferens
M	mouth	VO	vaginal orifice
MC	mantle collar	Z	digestive gland
O	oesophagus		

Oesophagus (O) entering stomach medially in male (Fig. 10), anteriorly in female (Fig. 11). Looping of intestine (I) also differing, aligned with stomach (IZ) in male (Fig. 10), linearly anterior to enlarged stomach in female (Fig. 11). Hindgut (HG) normally filled with faecal pellets, opening near anterior margin of mantle collar (MC) through a raised anal pore (A) (Figs 10, 11). Digestive gland (Z) distinctly larger in female (Fig. 11) than male (Fig. 10). Details of heart (H) and kidney (KD) not worked out.

Nervous system not studied because of limited material.

Male genitalia (Fig. 10) simple. Testis (T) with branched tubules along an apically running collecting duct, buried in base of digestive gland. Testis duct (TD) kinked apically, wider at first, narrowing after leaving digestive gland, entering seminal vesicle (SV) subapically. Seminal vesicle (SV) a narrow strip of tissue attached loosely to body wall, running just below kidney to enter prostate (DG), which is a mass of acinar tissue lying at apex of pallial cavity next to hindgut (HG). Collecting tubule of prostate zig-zags anteriorly, emerging as vas deferens (VD) at anterior margin of prostate. Branching of vas deferens occurs almost immediately. A slender "escape valve" (VDV) continues anteriorly to enter hindgut and the posteriorly directed main branch of the tube leads to the verge (DV) after complex coiling. Verge massive, located on back of neck, tip bifurcated with opening of vas deferens (DVO) through larger arm of bifurcation. Shaft of verge without bumps or other structures, exact internal passage of vas deferens through verge not determined.

Female genitalia (Fig. 11) simple. Ovary (OV) a single clump of large acini near base of digestive gland (Z). Oviduct relatively narrow and uncoiled down to level of seminal receptacle (RCS), which appears as an area of tight kinking in the oviducal tube. After one major curve, this enters apically into the pallial oviduct (PVO). Latter U-shaped, with a dorsal (PD) and ventral (POV) lobe. Vaginal orifice (VO) slightly posterior to anus (A). Spermatheca small, globose, on short duct.

The holotype, probably an adult female, is 5.00 mm in height, 3.59 mm in diameter, H/D ratio 1.39, with 5 1/2 whorls. Although collected alive, it had dried out subsequently.

Remarks: The name *letha* comes from the Greek *lethos*, referring to forgetting or escaping notice, an appropriate name for this rare and well-hidden species.

The dissected material from Cosy Corner (WAM 472.80) provided the impression that male shells were smaller and slightly squatter than females. This could not be documented by measurements as parts of the shells had been chipped away prior to study by Solem and thus could not be measured. The other live-collected and well-preserved set from Turner Brook (WAM 694.80) had most specimens retracted sufficiently that they could not be sexed without damaging or destroying the shell. Dried out materials from Cosy Corner and Deepdene could not be sexed. Thus, comparative measurements (Table 2) are based on lumped samples. Data is recorded only as mean and range for each area. The actual sex ratios and size differences are unknown.

Adult specimens were defined as those with both thickening of the basal lip and a beginning of irregular, gerontic growth visible behind the palatal lip. This gerontic growth may continue for more than an eighth of a whorl and in the very old and large specimens from Cosy Corner, the inside of the aperture has a substantial callus built up on all walls. All measurements were made with an ocular micrometer at x16, height and diameter accurate to within 2%, and whorls to within 1/8th accuracy. Differences among the samples are summarized in Table 2.

Specimens from Turner Brook below Deepdene Cliffs (WAM 694.80), collected 3 July 1980, are smallest in size and slightly lower in whorl count. They show the shortest area of gerontic growth and may well represent younger examples, rather than indicating a smaller "adult" size for that population. Specimens collected live, but aestivating, and freshly dead in September, October and November from Deepdene Cliffs (WAM 476.80), Ellen Brook (WAM 697.80, WAM 698.80), and Meekadorabbie Cave,

Ellen Brook (WAM 696.80) are distinctly larger in size and with noticeably greater thickening to the shell lip. The differences among these populations are not significant. The Cosy Corner samples, nearly all collected dead and many in bleached condition, are large (Table 2) and many show much greater thickening of the shell lip and noticeably longer gerontic growth. We cannot say if this population actually is larger, or if biased samples of mainly gerontic individuals have been taken.

Living specimens of *Austroassiminea letha* are known from three localities just north of Augusta. They are Turner Brook near Deepdene Cliffs, Cosy Corner, and Ellen Brook just north of the Margaret River. At Turner Brook they have been found in seepage areas at the base of limestone cliffs, or in litter near the creek banks in an area located only a few hundred metres from the creek mouth. Near the base of Deepdene Cliffs they were on rocks splashed by a miniature waterfall and on the ground above, a seepage area draining from the high limestone on the southern side of Turner Brook. At Cosy Corner they have been taken in grass tussocks on granite cliffs wet by seepage from the limestone-granitic rock contact above and located less than 200 metres from the beach. Dead shells are common in what we presume to be Holocene deposits, but live material has been found in an area of only a few square metres. At Ellen Brook, live material was taken in algae growing on the sides of concrete and wooden troughs carrying flowing water from Ellen Brook to the Ellensbrook homestead. The snails were in algal growth above the water line in the troughs. This site was several hundred metres from the stream mouth and significantly more elevated than the small sandy delta of Ellen Brook. Additional field work along Ellen Brook in September and October 1980 found specimens alive or freshly dead adjacent to the dam at Ellensbrook homestead and on moss and algal covered limestone forming the sides of the waterfall at the entrance to Meekadorabbie Cave and the banks of the brook above it. Specimens on soil, leaves and twigs were aestivating or recently dead. All of these localities, although near the ocean, are well above storm water marks and are not subject to sea water inundation.

Table 2
Size and shape variation in *Austroassiminea letha*

Locality	No. of adults measured	Mean (and range)			
		Shell Height (mm)	Shell Diameter (mm)	H/D ratio	Whorls
Turner Brook, below Deepdene Cliffs	20	3.94 (3.48-4.67)	2.91 (2.60-3.39)	1.35 (1.23-1.47)	5 1/4- (4 7/8-5 1/2+)
Deepdene Cliffs	25	4.39 (4.01-5.33)	3.20 (2.96-3.68)	1.39 (1.31-1.55)	5 3/8- (5-5 5/8)
Cosy Corner	120	4.76 (4.08-5.39)	3.42 (2.99-3.78)	1.39 (1.29-1.49)	5 5/8- (5 1/8-6 1/8-)
Ellen Brook	31	4.24 (3.45-5.16)	3.12 (2.70-3.52)	1.36 (1.27-1.47)	5 3/8- (5+-5 5/8)
Meekadorabbie Cave, Ellen Brook	31	4.14 (3.49-4.97)	3.08 (2.63-3.62)	1.34 (1.23-1.48)	5 3/8- (5-5 5/8)

Several visits to the Deepdene and Cosy Corner sites since 1963 demonstrate that the populations persist within very small areas. Extensive searches in similar-appearing habitats along the Deepdene Cliffs and near Cosy Corner have failed to reveal additional populations. At both Cosy Corner and Deepdene, ground areas remain moist even during the middle of summer, and live snails have the option of retreating into deeply fissured rocks back to the retracted water trickle that eventually forms the basal ground soak. All localities would be subject to heavy morning dews, another dependable source of water in this area of coast. Living specimens have been taken only at times when flowing water was in the seepage zones, but this may only be indicative of an extended foraging zone bringing them out into areas accessible to prying fingers of scientists. While water associated, they are in damp terrestrial habitats that are close to the water margin.

Because of the very limited populations observed, collections have been restricted mainly to samples of dead shells. Some early collections were dried and the anatomical data recorded here are based upon material from Cosy Corner (WAM 472.80) collected 22 June 1980 specifically for this review.

Fossil records

Evidence that *A. lethae* is an endemic relict comes from three fossil occurrences on the lower southwest coast of Western Australia. On the southern side of North Point ($34^{\circ} 09' 41''$ S, $115^{\circ} 01' 23''$ E), a 25 m sea cliff of Tamala Limestone (Playford *et al.* 1976) rises on a basement of Precambrian gneiss. It shows a sequence of four prominent, brown fossil soils, separated by units of paler aeolian calcarenite. A thin gneiss-calcrete conglomerate underlies the lowest fossil soil and is itself underlain at about HWM by a poorly exposed, marine shelly limestone; the limestone-gneiss contact is partly obscured by an apron of fallen boulders.

The lowest fossil soil, up to 2.3 m thick, lies in the splash zone and is being eroded vigorously. It is a brown, friable clayey to silty calcarenite, without obvious bedding structure and with thin bands of calcareous cementation; rhizoconcretions occur near the top and in the lower part occur pebbles and cobbles of near-black calcrete. This fossil soil contains a sparse land snail assemblage of four species—*Austroassiminea lethae*, *Bothriembryon* sp. and a species each of the Charopidae and Punctidae. Of the first mentioned, 15 specimens (WAM 68.385, WAM 81.19, FMNH 198759) have been collected, of which the largest has a height of 4.84 mm. This species has been found only in the lowest fossil soil and mainly within 0.6 m of its base. Numerous shells of other land snails, notably *Bothriembryon* sp., occur in the overlying fossil soils.

The section at North Point, including the basal marine unit, resembles others from the Cape Leeuwin-Cape Naturaliste coast described by Fairbridge and Teichert (1953) and Fairbridge (1953). The marine units were noted by Lowry (1967) and assigned a late Pleistocene age. All snails from the North Point fossil soils represent living species, which is consistent with a relatively "late" Pleistocene age. The presence of *Austroassiminea lethae* only in the lowest fossil soil indicates that the species last inhabited the

site during the accumulation of that unit. By analogy with modern occurrences of the present species, it seems likely that the site incorporated a freshwater discharge at the gneiss-limestone contact, which became buried beneath mobile aeolian sands early in the regression following the "Last Interglacial" of the Late Pleistocene. Other land snails were able to maintain populations on the sandy terrains that resulted from this episode of dune building, but not *Austroassiminea lethae*, which became extinct locally. With the return of sea level to its modern position about 6000 years ago (Mörner 1976), wave erosion established the fresh cliff section visible today.

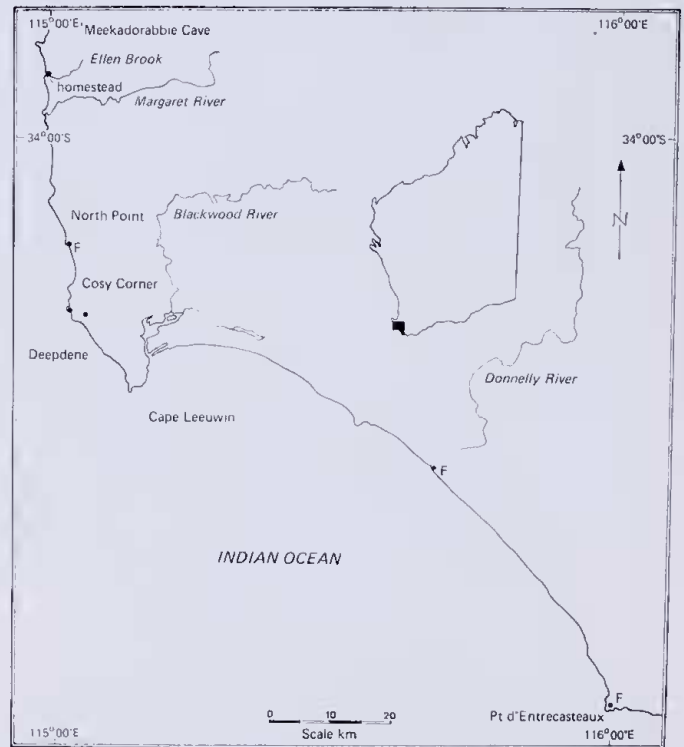


Figure 13.—Part of southwestern Australia with localities of *Austroassiminea lethae* sp. nov. shown by •. F denotes fossil locality.

A calcareous, sandy fossil soil, reported to lie at about 2.5 m above sea level is exposed within a coastal cliff of aeolian calcarenite behind a sandy beach about 0.8 km SE from the mouth of the Donnelly River ($34^{\circ} 29' 24''$ S, $115^{\circ} 40' 38''$ E). Five shells of *Austroassiminea lethae* (WAM 70.2691, 70.2692) were collected from this deposit, the height of the largest being 5.07 mm. Other land snails present included species of *Succinea*, *Bothriembryon*, Charopidae and Punctidae. All of these species appear to be extant and a Late Pleistocene age is probable. We have not examined this isolated locality and are unable to comment on the presence or otherwise of any freshwater discharge, past or present, at the site.

The elevated limestone headland of Pt d'Entrecasteaux ($35^{\circ} 50' 32''$ S, $115^{\circ} 59' 40''$ E) features several exposures of lithified fossil soils with land snail shells (Kendrick 1978). The assemblage includes species of Charopidae and Punctidae, two extinct species of *Bothriembryon* and *Austroassiminea lethae* (WAM 70.895, 70.897, 70.898), height of the largest 4.47 mm. These fossil soils are

probably of Pleistocene age and their snail assemblage suggested to Kendrick (1978) "a humid, well-vegetated, probably forested environment . . ., in contrast to the exposed coastal heath that presently characterizes the area". The deposits lie about 100 m above sea level and overlie a substantial thickness of porous, sandy limestone. They are dispersed over several square kilometres of open terrain, with no evidence of concentrated freshwater discharge or seepage, such as those associated with modern populations of *A. lethia*. This association of *Austroassimineia lethia* with forest litter snails is puzzling. We are not agreed as to whether *A. lethia* was either dispersed more or less generally on the leaf litter of a forest floor, under conditions of higher and more sustained levels of humidity than now prevail in the area (Kendrick), or washed in from nearby localities featuring its current habitat (Solem). Of the three fossil localities reported here, only Pt d'Entrecasteaux contains extinct species and we conclude from this that it is the oldest geologically. A more precise dating of this deposit within the Pleistocene is not possible at present. We suggest that the Pt d'Entrecasteaux records of *A. lethia* antedate, wholly or in part, the events which led to the severe fragmentation of the species' modern range.

Conclusions

The recent and fossil distribution data indicate that *Austroassimineia lethia* had a more extensive range in the geologically recent past. Three of the six known occurrences are fossil only and indicate a high rate of local extinction by natural processes. It is now relatively abundant at each of three localities in areas of only a few square metres. Human activities could easily extinguish each extant colony. We thus consider it to be both a rare and endangered species.

The absence of any other amphibious or terrestrial assimineid from Australia is remarkable in view of the wide distribution that terrestrial members of the family have from South-east Asia into Polynesia. We can offer no reasons for the lack of representation in northern and eastern areas of the continent. The presence of a species in the south-western tip of Australia suggests that it is a Gondwanic relict. The fact that the anatomical features of this species combine aspects of both recognized subfamilies of the Assimineidae, may have major phylogenetic implications. If the characters used by Abbott (1949) to delineate subfamily units are significant, the combination in *Austroassimineia lethia* of features from both subfamilies may indicate that it is close to the ancestral condition, a phylogenetic relict as well as geographic. It is also possible that the selection of subfamilial characters is in error, but until modern revisions of the Indonesian to Polynesian taxa are available, this question cannot be settled.

Regardless of its exact phylogenetic position, *Austroassimineia lethia* represents a significant addition to the fauna of Western Australia, and is a species reduced to remnant populations that can be wiped out by man unless they are afforded protection from environmental pollution and habitat destruction.

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